



US010277419B2

(12) **United States Patent**
Huber

(10) **Patent No.:** **US 10,277,419 B2**
(45) **Date of Patent:** **Apr. 30, 2019**

(54) **HYBRID NETWORK END SYSTEM DEVICE**

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(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 9 days.

(21) Appl. No.: **15/601,771**

(22) Filed: **May 22, 2017**

(65) **Prior Publication Data**

US 2017/0353329 A1 Dec. 7, 2017

(30) **Foreign Application Priority Data**

Jun. 1, 2016 (DE) 10 2016 110 150

(51) **Int. Cl.**

B60P 3/00 (2006.01)
G06F 3/06 (2006.01)
H04L 12/46 (2006.01)
H04L 12/931 (2013.01)
H04L 12/947 (2013.01)

(52) **U.S. Cl.**

CPC **H04L 12/4625** (2013.01); **G06F 3/0634**
(2013.01); **H04L 49/25** (2013.01); **H04L**
49/351 (2013.01); **H04L 49/60** (2013.01);
H04L 49/65 (2013.01); **B60P 3/00** (2013.01);
G06F 2206/1008 (2013.01)

(58) **Field of Classification Search**

None
See application file for complete search history.

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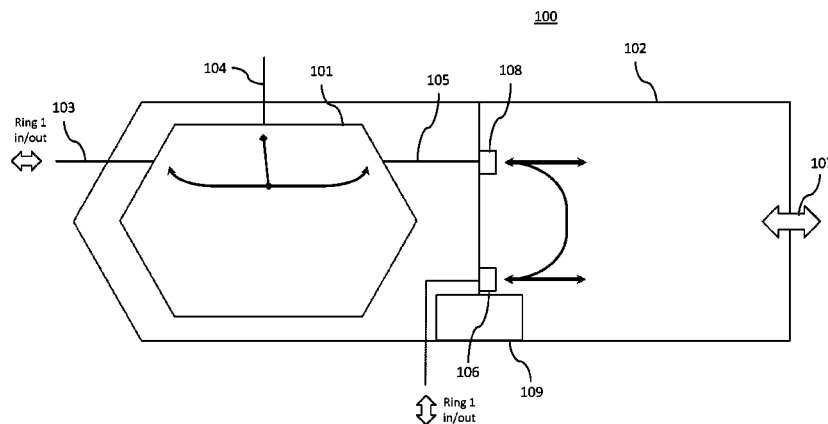
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(57) **ABSTRACT**

Provided is a hybrid network end system device for a network system with an end system unit and a switch. The switch here exhibits at least one first port of the switch and a second port of the switch for connection with the network system.

10 Claims, 11 Drawing Sheets



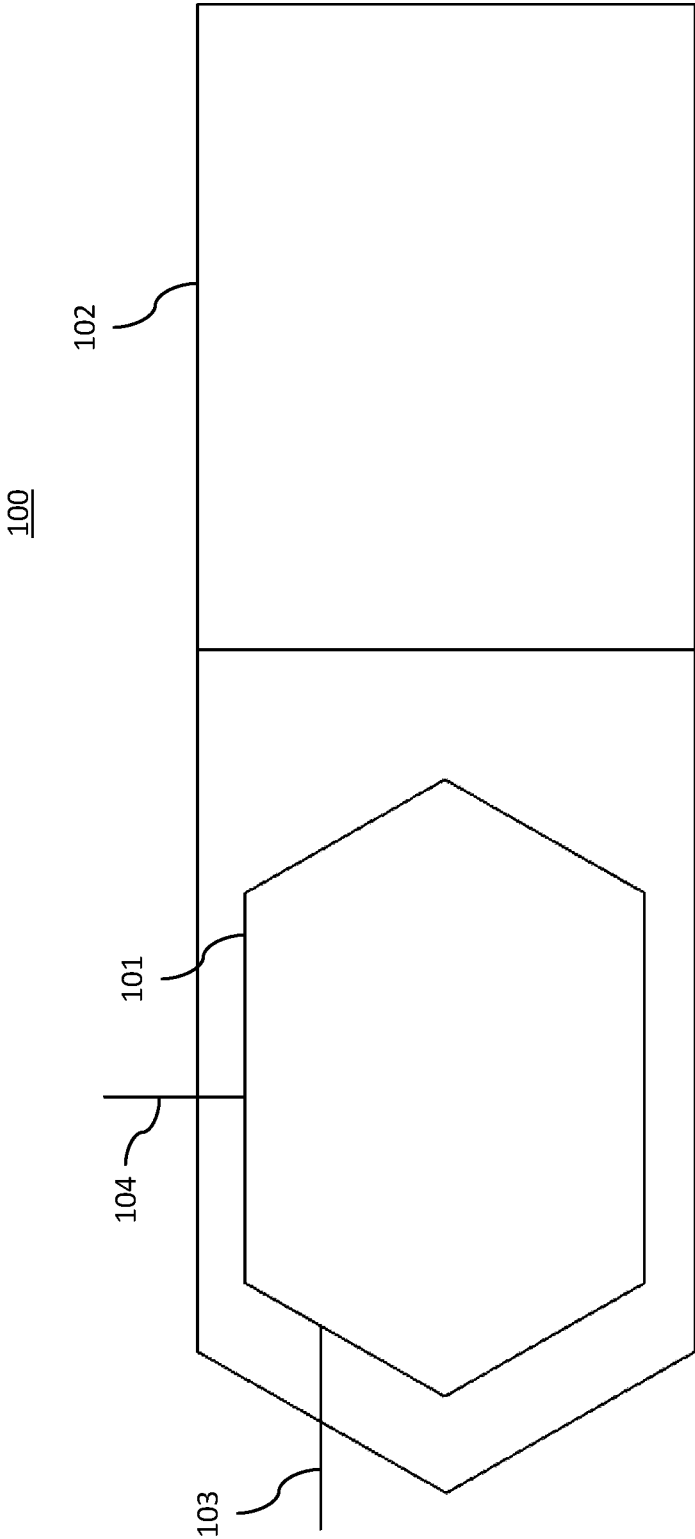


Fig. 1

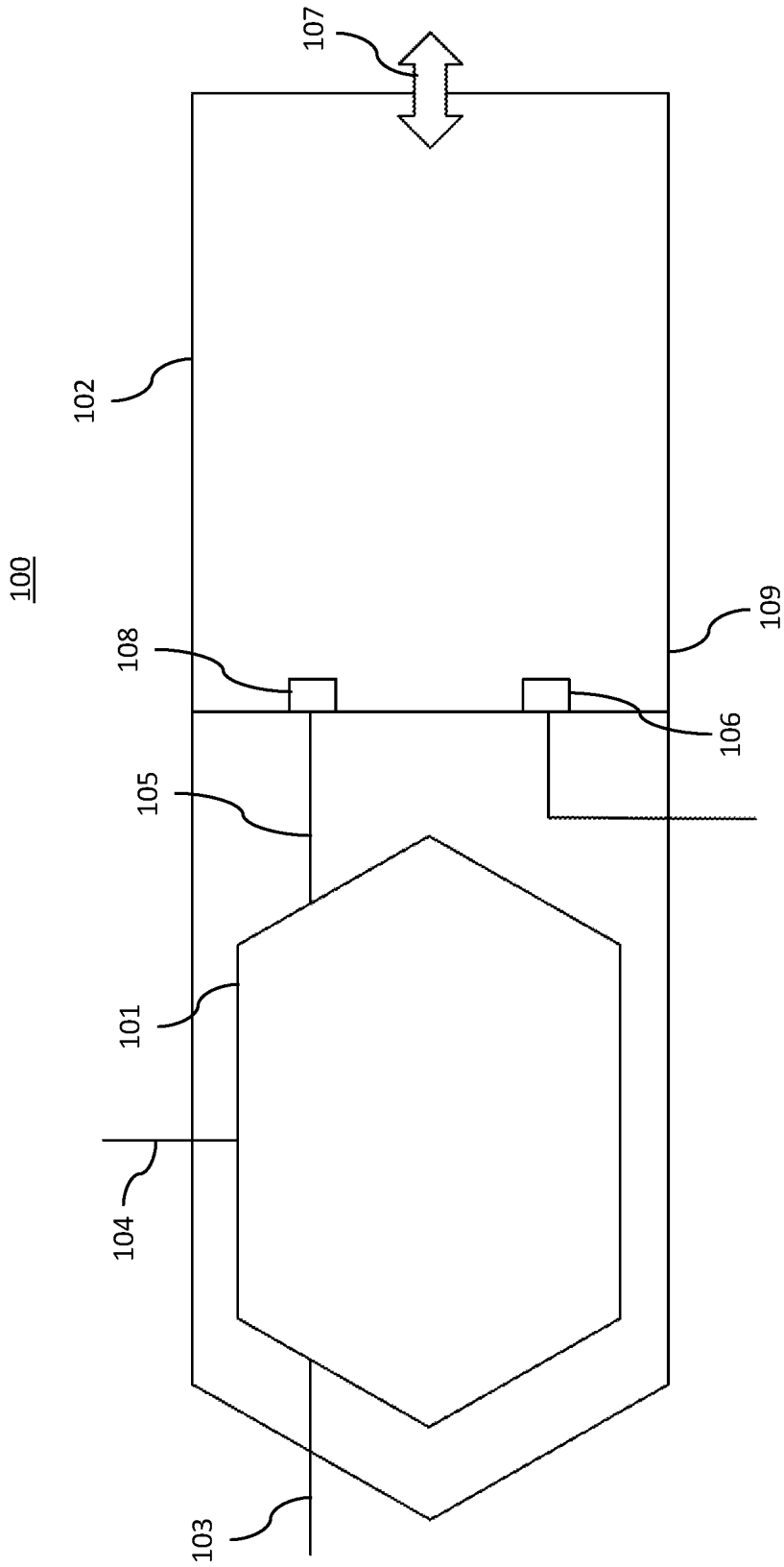


Fig. 2

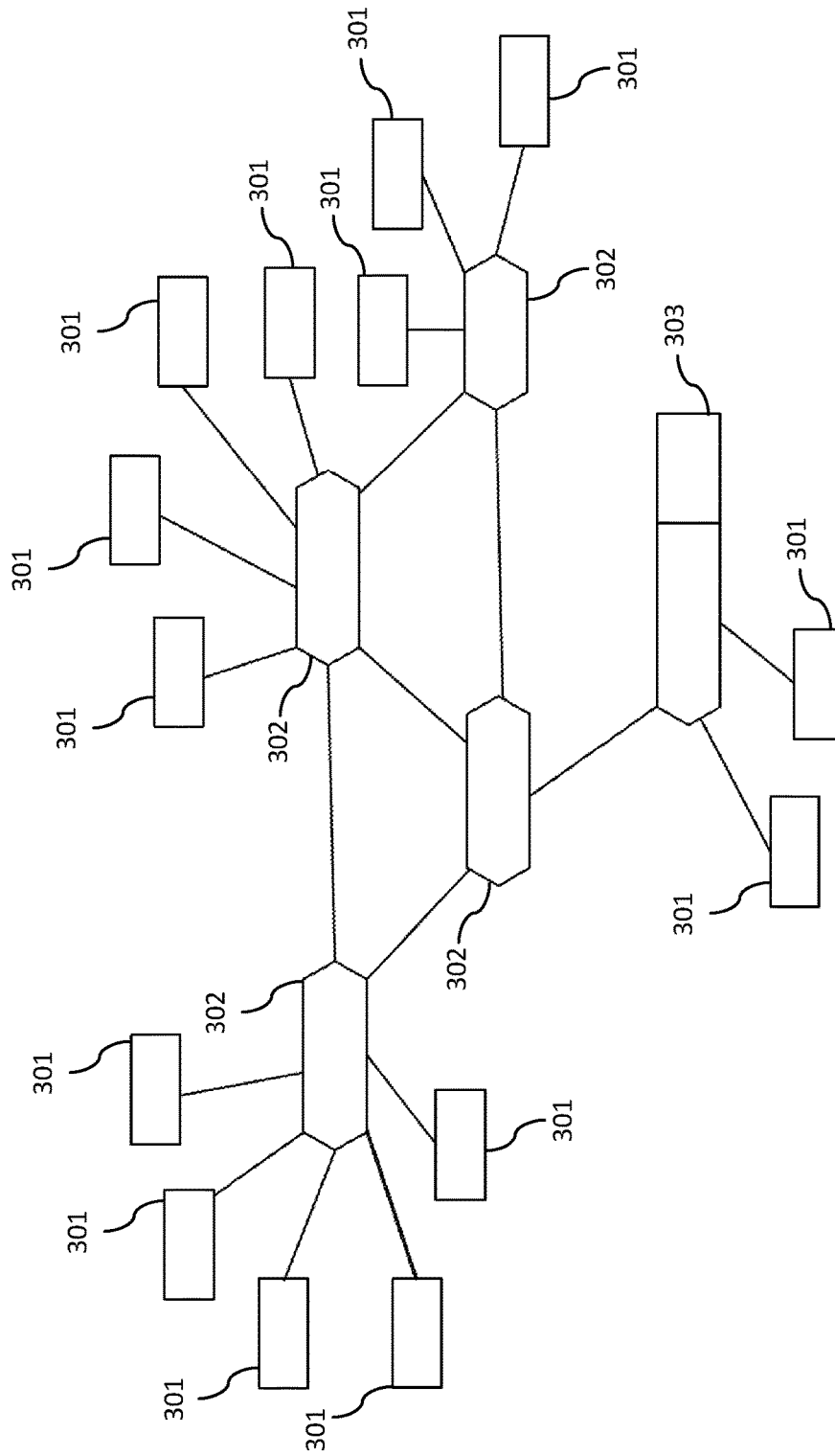


Fig. 3

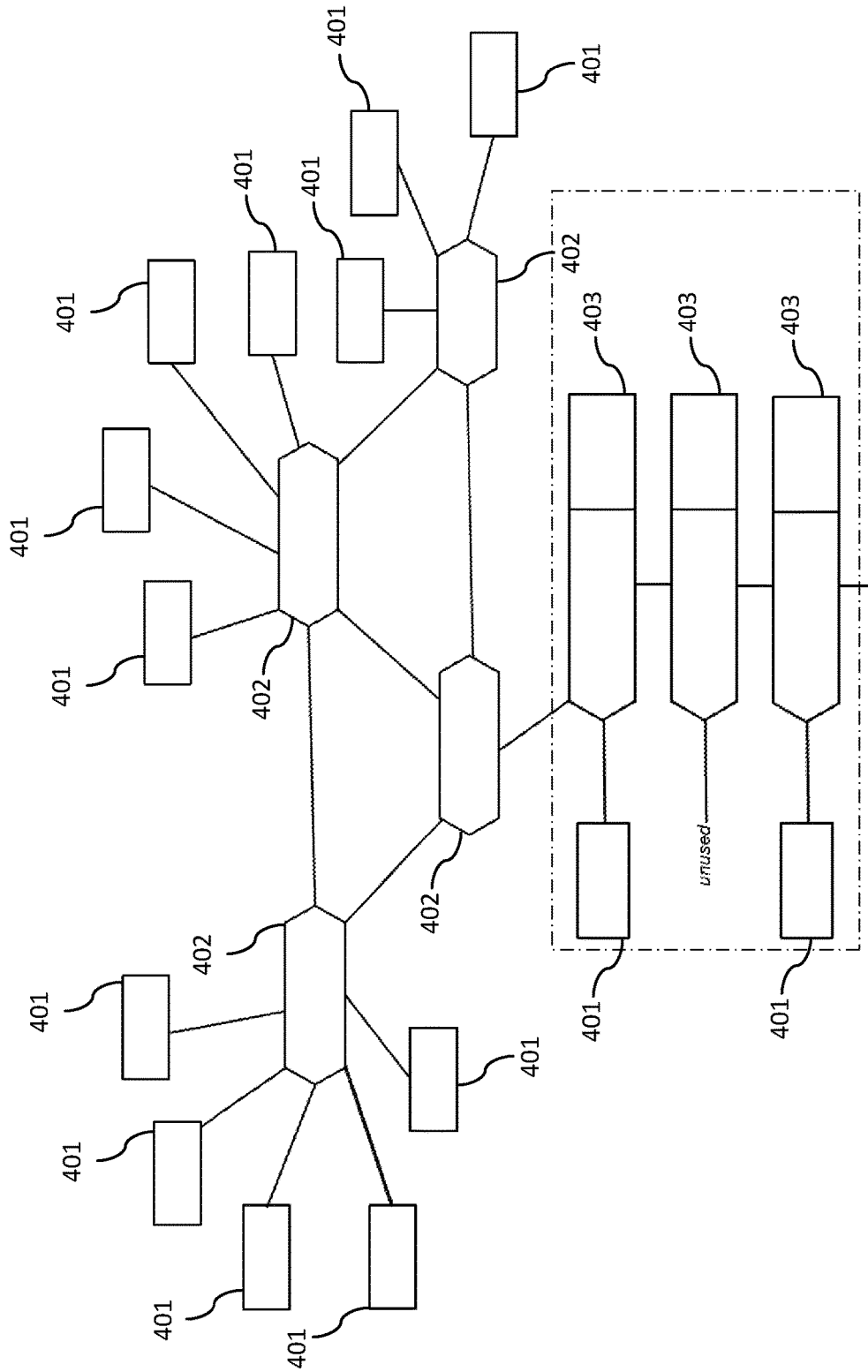


Fig. 4

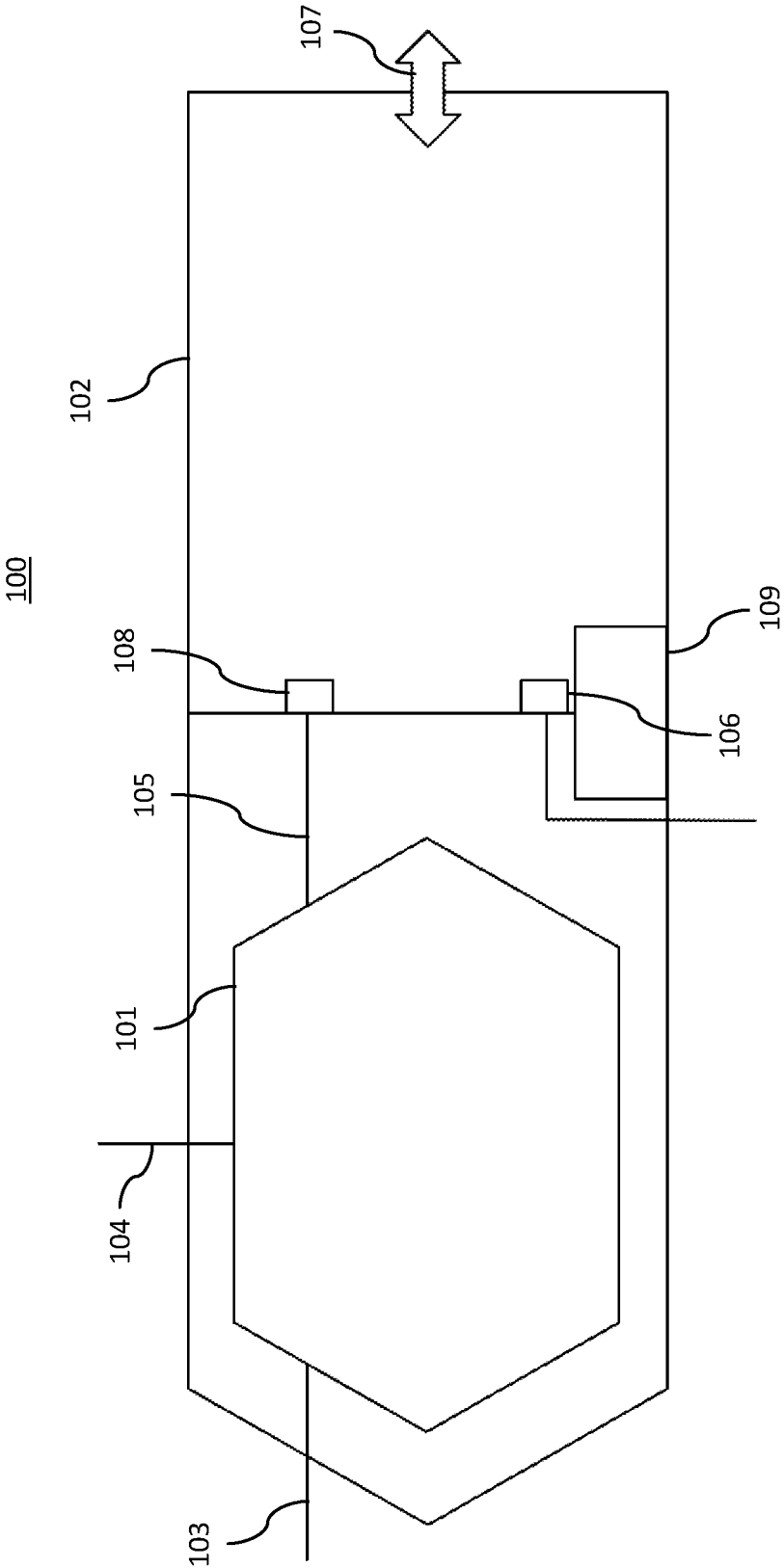


Fig. 5

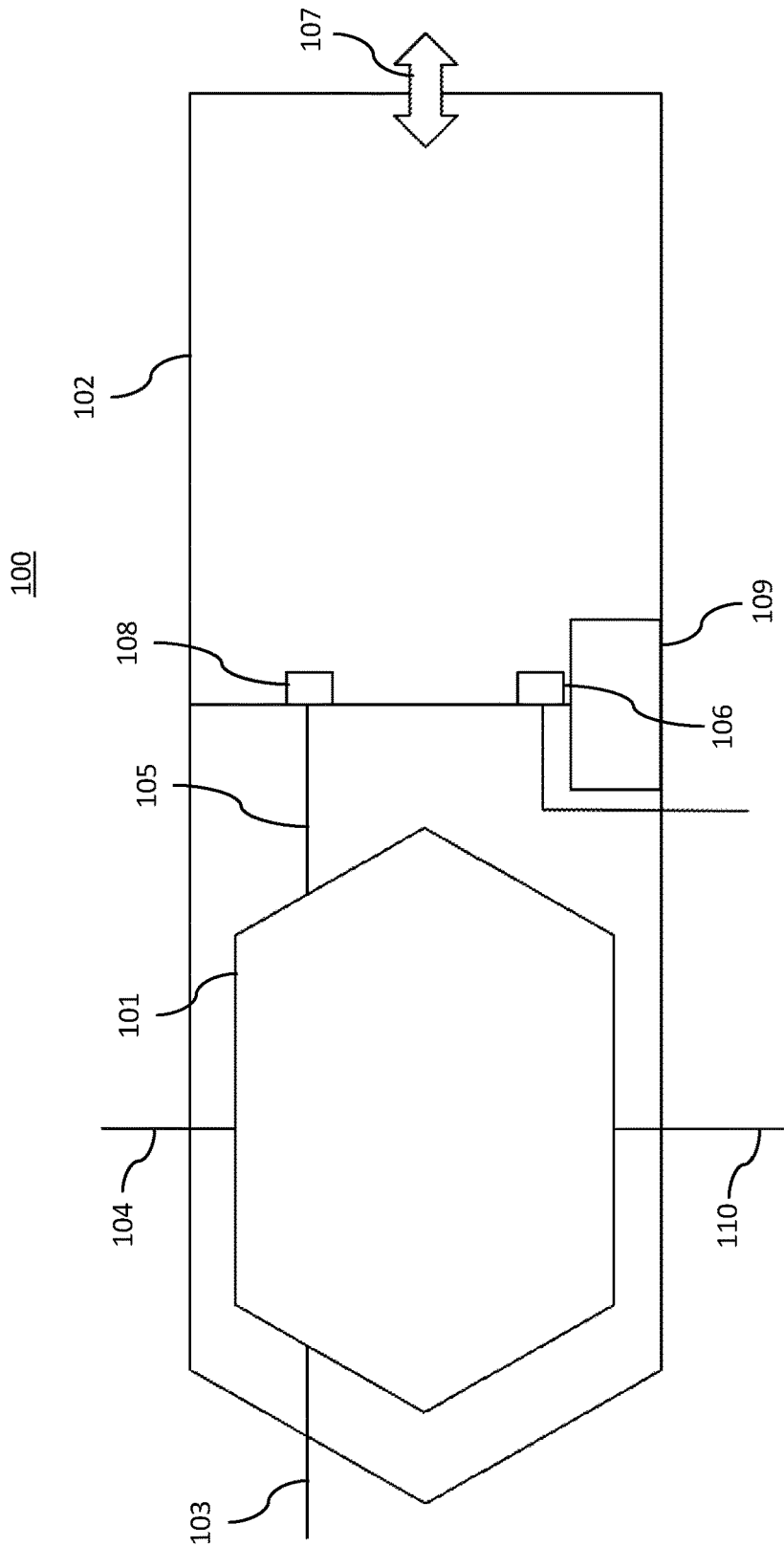


Fig. 6

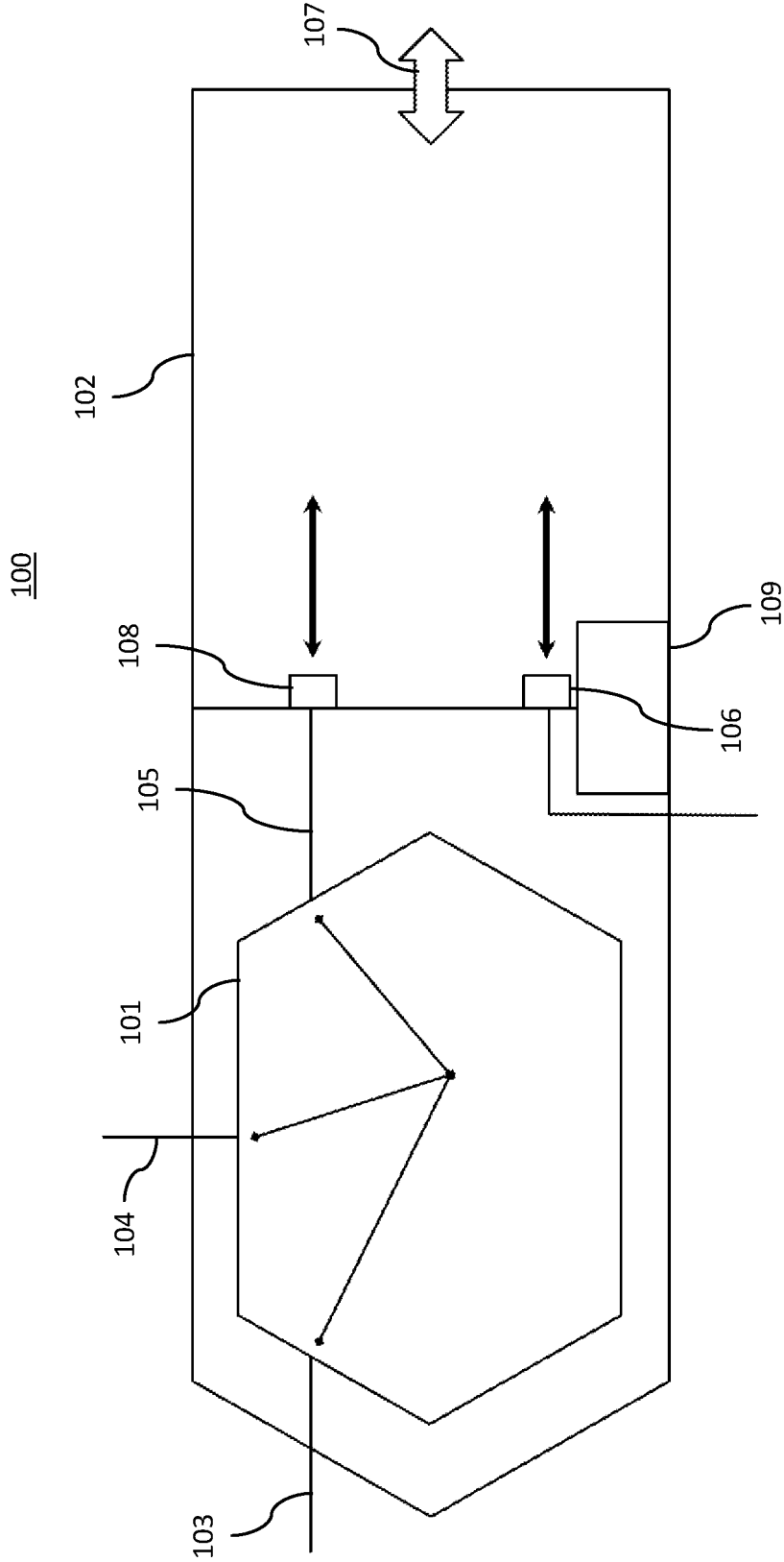


Fig. 7

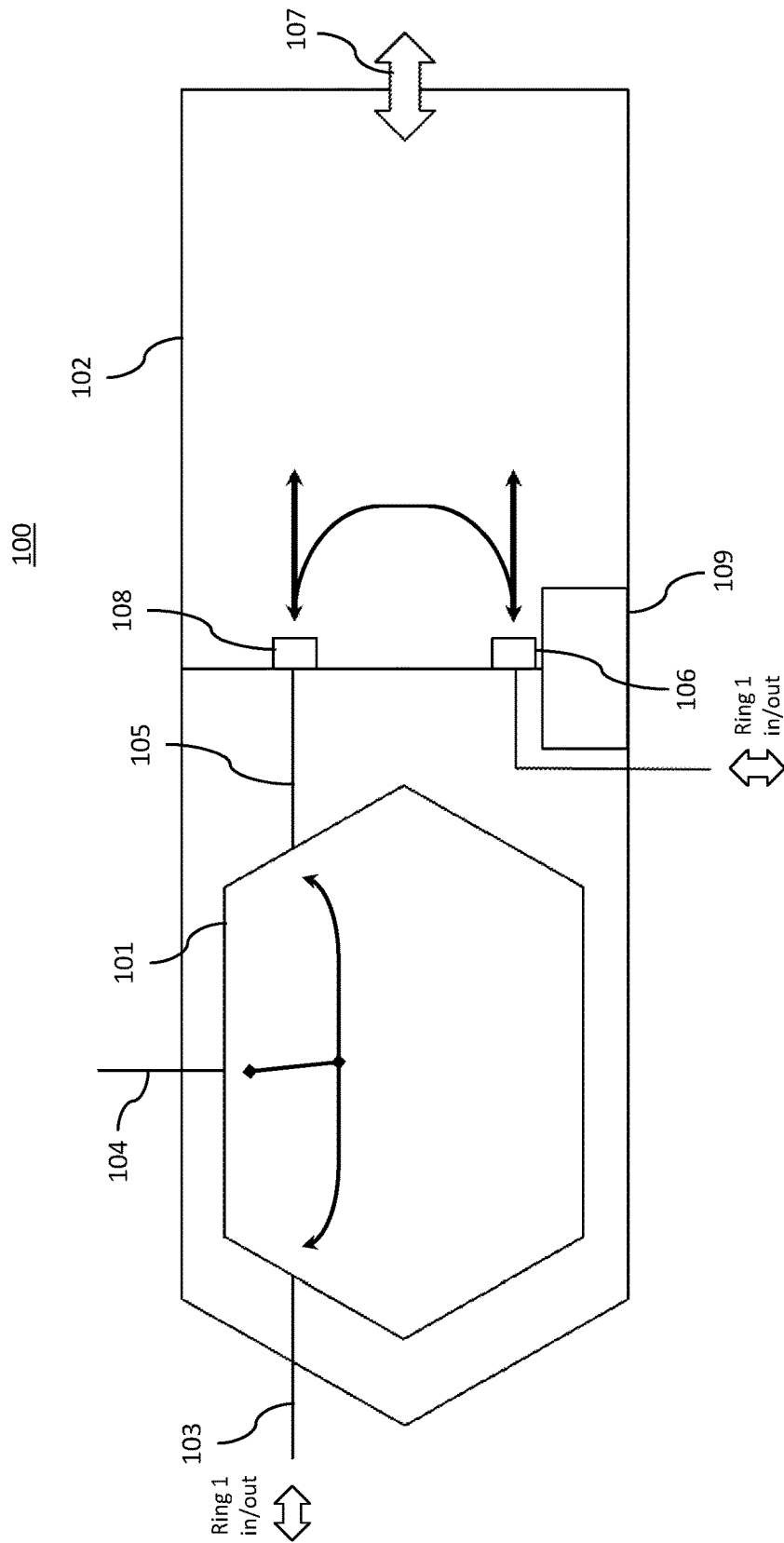


Fig. 8

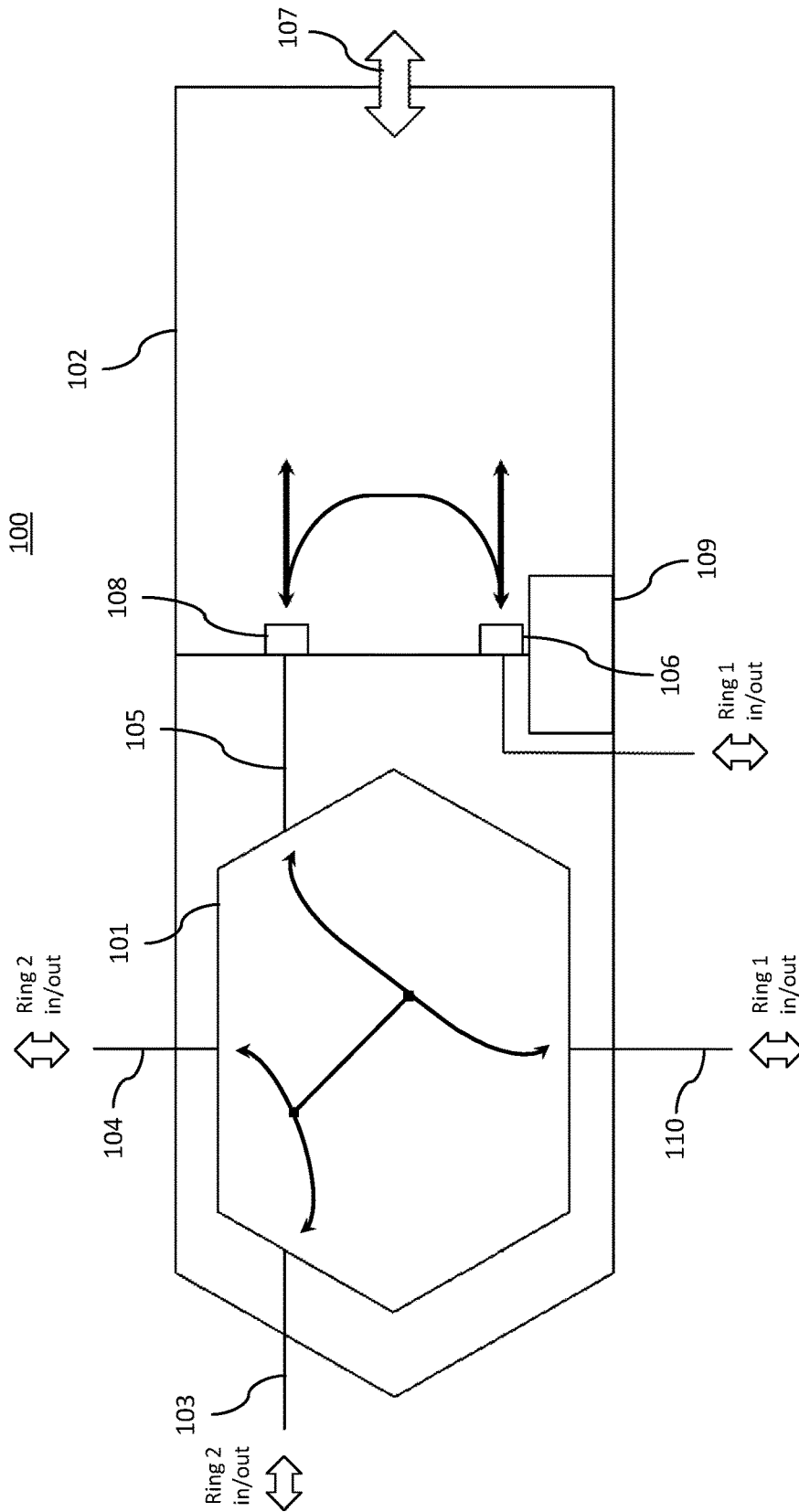


Fig. 9

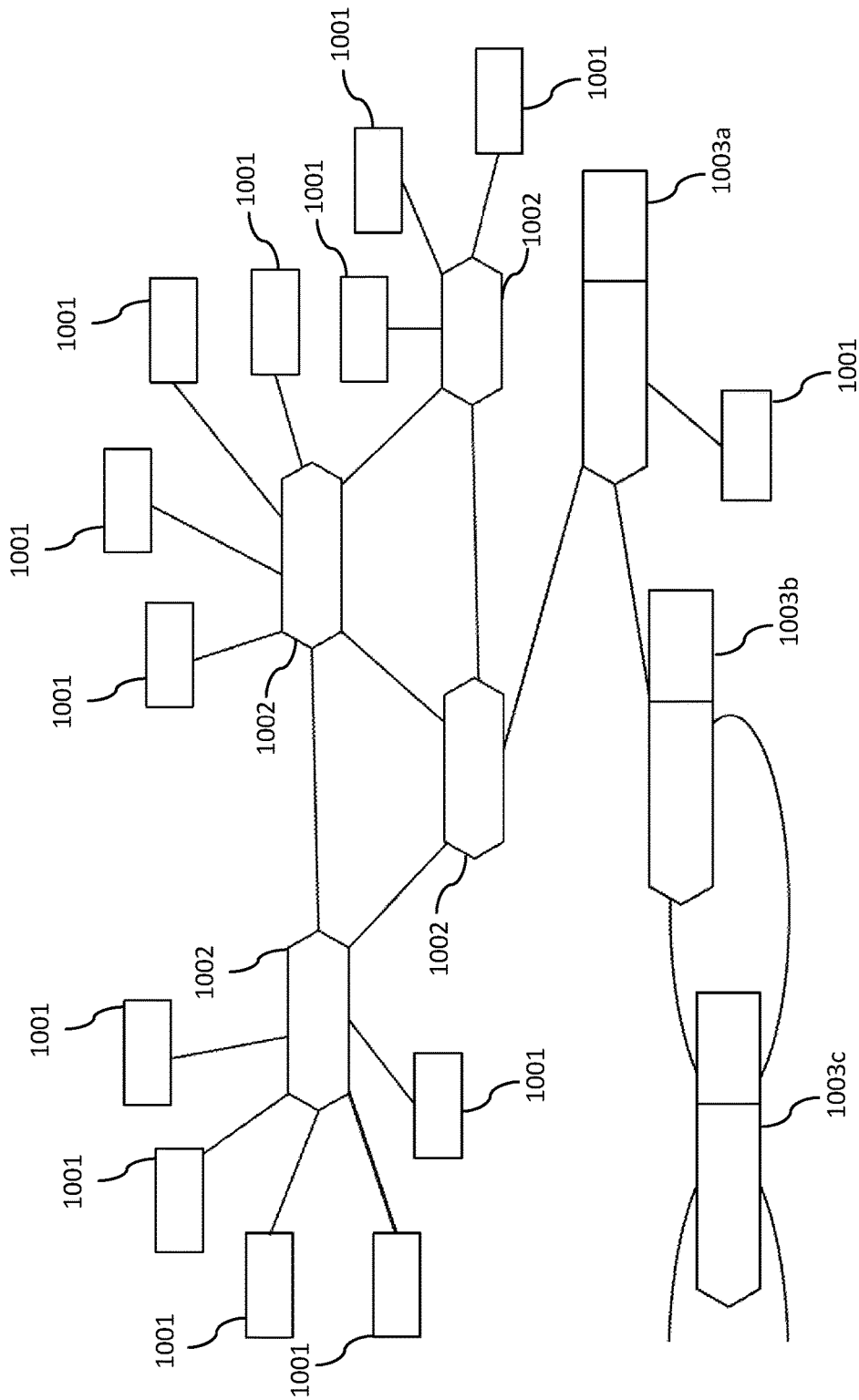


Fig. 10

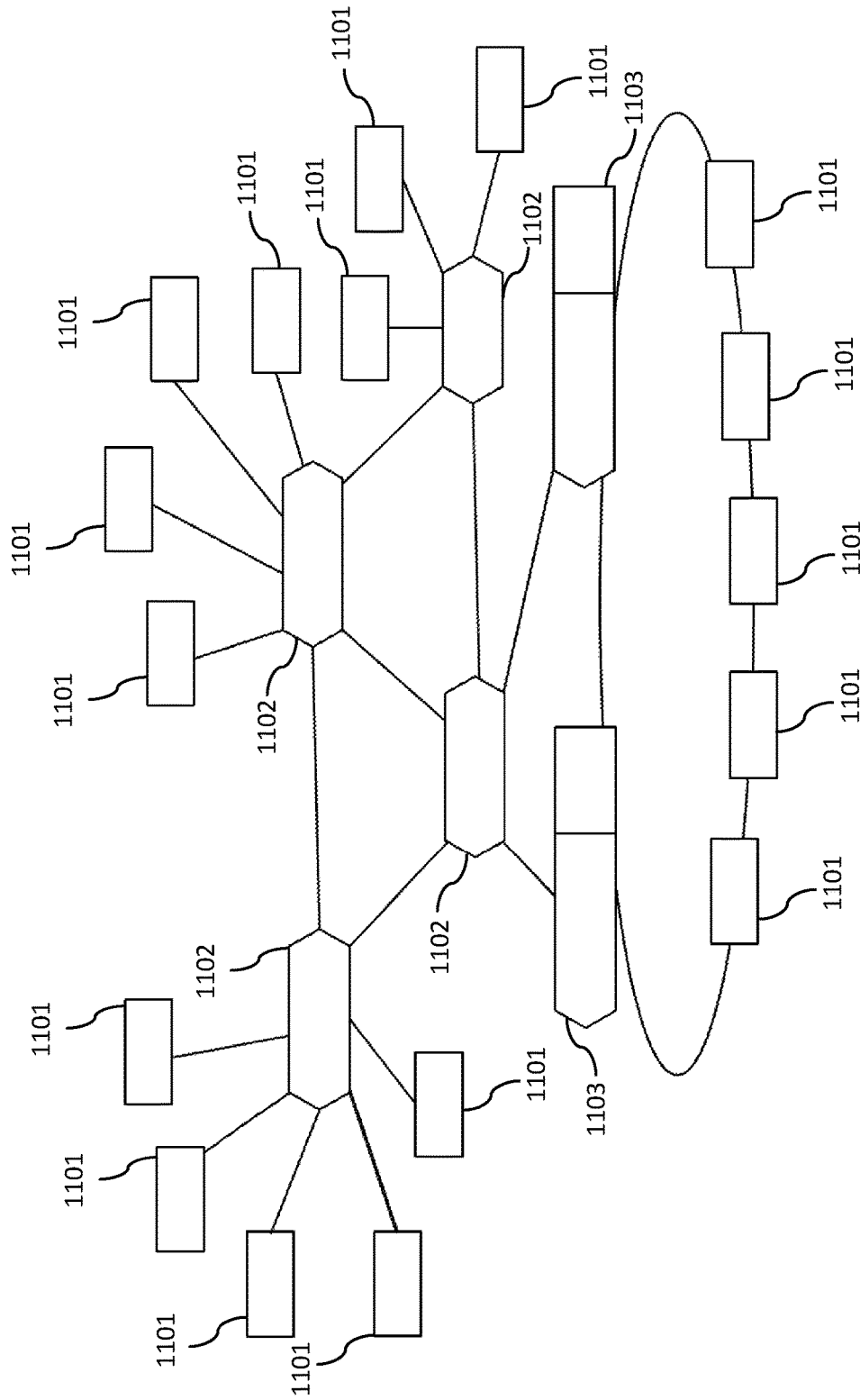


Fig. 11

HYBRID NETWORK END SYSTEM DEVICECROSS-REFERENCE TO RELATED
APPLICATION

This application claims the benefit of, and priority to, German patent application number DE 102016110150.8, filed on Jun. 1, 2016.

TECHNICAL FIELD

Embodiments of the present invention relate to the technical area of networks for communication between end systems, and in particular to a hybrid network end system device with an integrated switch for such a network.

BACKGROUND

For example, Avionics Full Duplex Switching Ethernet (AFDX) is used for communication between aircraft systems, which is a conventional designation for ARINC Standard 664. This standard describes a network and the accompanying protocol for communication between aircraft systems.

In such AFDX networks, AFDX end systems are connected in a star topology by means of switches in point-to-multipoint connections (P2MP). To ensure redundancy, the network is duplicated. The network system thus encompasses a first network and a second network, which are built independently of each other. The data of the network end system are here output via two ports of the network end system to the independent networks.

In addition, the protocols High Availability Seamless Redundancy (HRS) and Parallel Redundancy Protocol (PRP) are used to ensure redundancy, in particular in networks of industrial and power plant automation. The latter are described in the IEC 62439-e standard.

BRIEF SUMMARY

It may be desirable to provide an improved network end system.

Accordingly, a hybrid network end system device, a network system as well as a vehicle can be provided according to certain embodiments of the present invention.

Exemplary embodiments and other aspects are indicated by the subject matter of the independent claims and of the following description.

In one aspect, a hybrid network end system device for a network system encompasses an end system unit and a switch. The switch here comprises at least one first port of the switch and a second port of the switch for connection with the network system.

In one aspect, a network system for communication between end systems encompasses at least one, in particular at least two, hybrid network end system device(s) according to an aspect of the present invention.

In one aspect, a vehicle, in particular an airplane, encompasses at least one, in particular two, hybrid network end system device(s) according to an aspect of the present invention.

This summary is provided to introduce a selection of concepts in a simplified form that are further described below in the detailed description. This summary is not intended to identify key features or essential features of the

claimed subject matter, nor is it intended to be used as an aid in determining the scope of the claimed subject matter.

BRIEF DESCRIPTION OF THE DRAWINGS

Additional exemplary embodiments of the present invention will be described below, drawing reference to the figures.

FIG. 1 shows a schematic view of an embodiment of the hybrid network end system device.

FIG. 2 shows another embodiment of the hybrid network end system device.

FIG. 3 shows a network system with a hybrid network end system device according to one of the embodiments.

FIG. 4 shows another network system with several hybrid network end system devices according to one of the embodiments.

FIG. 5 shows another embodiment of a hybrid network end system device.

FIG. 6 shows another embodiment of the hybrid network end system device.

FIG. 7 shows a configuration of the hybrid network end system device in a first mode.

FIG. 8 shows a configuration of the hybrid network end system device in a second mode.

FIG. 9 shows the configuration of the hybrid network end system device in a third mode.

FIG. 10 shows a network system with several hybrid network end system devices in varying modes.

FIG. 11 shows the use of several hybrid network end system devices in the second mode.

DETAILED DESCRIPTION

The following detailed description is merely illustrative in nature and is not intended to limit the embodiments of the subject matter or the application and uses of such embodiments. As used herein, the word “exemplary” means “serving as an example, instance, or illustration.” Any implementation described herein as exemplary is not necessarily to be construed as preferred or advantageous over other implementations. Furthermore, there is no intention to be bound by any expressed or implied theory presented in the preceding technical field, background, brief summary or the following detailed description.

The illustrations on the figures are schematic and not to scale. In the following description of FIGS. 1 to 11, the same reference number is used for identical or corresponding elements.

FIG. 1 shows a hybrid network end system device **100** according to a first exemplary embodiment. The hybrid network end system device **100** for a network here encompasses an end system unit **102** and a switch **101**. As depicted, the switch **101** here exhibits at least one first port **103** of the switch and a second port **104** of the switch for connection with the network system.

Thus shown is an end system device that has a dual function, specifically functioning as an end system unit and as a switch. Given the twofold functionality as an end system unit of a network and simultaneously as a switch, the unit is referred to as a hybrid network end system device.

In contrast to the prior art described above, such hybrid network end system devices can be connected to each other even without interposing a separate switch by integrating a switch or a configurable, active network element into a unit,

i.e., integrally, as an implementation with an end system. This enables a more flexible construction of the communication networks.

FIG. 2 shows a preferred embodiment of such a hybrid network end system device **100**. As evident from FIG. 2, the hybrid network end system device **100** on FIG. 2 differs from the one on FIG. 1 by having another (third) port **105** of the switch, which is connected with the end system unit **102**. To this end, the end system unit **102** has a first port **108** of the end system unit **102** for communication with the switch **101**. The end system unit **102** further has a second port **106** of the end system unit **102** for communication with the network system. A local interface **107** of the end system unit **102** is used for connection with local components of the end system, and thus for local communication. For example, this local interface **107** can be designed as a CPU interface or host-CPU interface. As opposed to ports **103**, **104** and **106**, the local interface **107** is thus used for a local combination with local components, and not for combination with a network system.

The first **103** and second **104** port of the switch here preferably is used for communication with a first network of the network system, and the second port **106** of the end system device is used for communication with a second network of the network system, and is configured accordingly. As a consequence, the hybrid network end system device **100** can be used for communication in a network system with two independent networks, for example an AFDX network, wherein the switch **101** is here connected with a first network of the independent networks, and a connection is established with the second network via the second port **106** of the end system unit.

In another exemplary embodiment not shown on the figures, a second switch can be provided, which is connected with the second port **106** of the end system unit **102**, and identical in design to the switch **101** described above and depicted on the figures. The statements thus apply accordingly. The second switch here is used for integration into the described second network of the network system.

FIG. 3 shows the use of such hybrid network end system devices **100** in a communication network or in a network system. Apart from conventional end systems **301** of the network system and conventional switches **302** of the network system, use is made of a hybrid network end system **303**. As evident from the figure, the hybrid network end system **303** makes it possible to directly connect other end systems without the use of additional switches, thereby enabling a more flexible structure.

FIG. 4 shows another network system with the use of hybrid network end system devices. Several hybrid network end system devices **403** are shown in addition to the conventional end system devices **401** and conventional switches **402**. In the present example, these are connected in series. This is generally also referred to as daisy chaining the hybrid network end system devices **403**, since several hybrid network end system devices are connected in series one after the other. In the case of aircraft system cabling, for example in large or elongated areas like wings, the cabin, etc., this makes it possible to connect the hybrid network end system devices or other conventional end system devices at a reduced cabling outlay and with an elevated flexibility.

FIG. 5 shows another exemplary embodiment of a hybrid network end system device. In general, the latter differs in that a control device is provided in the hybrid network end system device.

According to the above description, the hybrid network end system device **100** comprises a switch **101** and an end

system unit **102**, as evident from FIG. 5. With regard to the first, second and third ports **103**, **104** and **105** of the switch, let reference be made to the above description. The same holds true for the first and second ports of the end system unit and the local interface **106**, **108** and **107**.

The hybrid network end system device **100** on FIG. 5 further comprises a control unit **109**. This control unit **109** is designed to switch the switch **101** into several modes.

If the switch **101** is switched into a first mode by the control unit **109**, data or data packets arriving at the first port **103** of the switch, the second port **104** of the switch or the third **105** port of the switch are relayed either to the first port **103** of the switch, the second port **104** of the switch or the end system unit **102** via the third port **105** of the switch **101**, or output to the respective other port after received at the respective port.

Such a controller is described on FIG. 7. As evident, the switch **101** is operated in a star topology corresponding to a conventional switch. Data or data packets received at the ports **103**, **104**, **105** of the switch are preferably relayed or routed according to their content to the respective responsible port. For example, if a packet **103** is received at the first port **103**, the switch **101** checks for which port the data are intended, and outputs them to the respectively responsible port.

As also shown on the figure, the end system device **102** in this operating mode is set up to relay data received at the first port **108** for communication with the switch **101** or at the second port **106** for communication with the network system to the local interface **107**. Accordingly, the data received at the local interface **107** are preferably output to both the first port **108** and to the second port **106** of the end system unit **102**, so that, if the end system unit **102** is connected with a first network via the switch **101** and with a second network of two independent networks via the second port **106** of the end system unit **102**, all data or data packets of the local interface **107** are disseminated via both networks or can be received from both networks.

The end system device **102** is here preferably designed in such a way that it relays the data or data packet received at the first port **108** or the second port **106** to the local interface **107** if no copy of the data or data packet was received at the end system device **102** chronologically prior to receiving the data or data packet. The determination of a copy can here take place using a sequential number or user data of the received data or received data packet, for example. For example, the end system device **102** can accordingly be set up to check whether data or a data packet with an identical sequential number or identical user data have already been received, and correspondingly implement the transfer or discard the received data or the received data packet if a copy of the data or data packet was received at the end system device **102** chronologically prior to receiving the data packet. Therefore, it is evident to the expert that not all data or data packets received at the first port **108** and the second port **106** must be relayed to the local interface.

Let it be noted that there exists the possibility of also connecting a switch with the second port **106** of the end system unit **102** that is similar to or identical to the switch **101** in design and used for communication with the second network of two independent networks of the network system.

The control unit **109** can further be designed to switch the switch **101** into a second mode. In this mode, the data or data packets received at the first port **103** of the switch **101** are relayed to the end system unit **102** via the third port **105** of the switch, and data received at the third port **105** of the

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switch are relayed to the first port **103**. It is here preferred that, if the switch **101** is switched into the second mode, the end system device **102** be set up in such a way or the end system device **102** be controlled by the controller **109** in such a way that data received at the first port **108** of the end system unit **102** be relayed to the second port **106** of the end system unit **102**, and data received at the second port **106** of the end system unit **102** be relayed to the first port **108**.

Such a second mode will be described drawing reference to FIG. **8**. As evident, a ring here arises between the first port **103** of the switch **101** and the second port **106** of the end system unit **102**. Data or data packets received at the first port **130** of the switch **101** are thus annularly relayed via relaying to the third port **105** of the switch **101**, receiving at the first port **108** of the end system device **102** and relaying to the second port **106** of the end system device **102**.

This type of control, preferably by means of the control unit **109**, makes it possible to operate the hybrid network end system device **100** in a ring mode, and thus integrate the latter into a network ring or into a ring topology using the first port **103** of the switch **101** and the second port **106** of the end system unit **102**.

The end system unit **102** preferably determines whether the data are intended for it. If this is not the case, it outputs the data at its respective other port, and the data are disseminated further in the same direction in the annular network. If the data are intended for the end system device **102**, i.e., if the end system device is the destination end system device of the data or data packet, it relays the latter to their local interface **107**. Since the data are disseminated over the network in two directions, the destination end system device at a later point in time again reaches the same data or the same data packet at the other port of the destination end system device. The latter is then preferably discarded by the switching device. An end system device is here further preferably designed to check whether it has already relayed the data packet or a copy thereof. If this is the case, the switching device of the end system device is preferably designed to discard the data packet. Therefore, it is obvious to the expert that not all data or data packets received at the ports of the end system device **102** must be relayed to the respective other port.

In addition, as also shown on FIG. **8**, it is possible to implement a type of control where data or data packets received at the second port **104** of the switch **101** are further coupled into the ring comprised of the first port **103** of the switch **101** and the second port **106** of the end system device **102**. Apart from the transfer described above, an indication is to this end preferably made at the second port **104** of the switch **101** inside of the switch **101** if the switch **101** determines that received data or a received data packet are/is intended for the second port **104**. Alternatively, all data received at the first **103** or the third **105** port of the switch can also be output to the second port **104** of the switch **101**. Accordingly, data or data packets received at the second port **104** of the switch are coupled into the ring network comprised of the first port **103** of the switch **101** and the second port **106** of the end system device **102** by outputting the data packets or data received at the second port **104** of the switch **101** to one or both ports **103** and **015** of the switch **101**.

A third mode will now be described based on FIGS. **6** and **9**. In another embodiment, the switch **101** of a hybrid network end system device **100** here comprises a fourth port **110** of the switch **101**, as shown on FIG. **6**.

The control unit **109** is here designed to switch the switch **101** into a third mode. In the third mode, the switch **101** is set up to output incoming data at the ports of the switch to

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the two outgoing ports of the switch of both rings. For example, data received at the first port **103** are multiplied or replicated and output to the second **104** port, i.e., to the corresponding outgoing port of the same ring, as well as to the fourth **110** port, i.e., to the corresponding outgoing port of the additional ring of the switch **101**. In other words, the data at one port of each ring, i.e., in the present case two rings, are output to two ports serving as outgoing or output ports of the rings. This operation is also referred to as quad box operation.

If the control unit **109** has switched the switch into the third mode, it is preferred that the end system device **101** be set up or controlled by the control device **109** in such a way that data received at the first port **108** of the end system device **102** are relayed to the second port **106** of the end system unit **102**, and data received at the second port **106** of the end system device **102** are relayed to the first port **108** of the end system unit **102**. With respect to relaying in the end system device, in particular relaying to the local interface and to the respective other port, the above description applies accordingly to the second mode.

Such a configuration is shown on FIG. **9**. As evident here, using the third mode, which can also be referred to as the quad box mode, permits the coupling of several ring networks. For example, on FIG. **9**, the fourth port **110** of the switch and the third port **105** of the switch via the transfer of the end system unit **102** form a ring with the second port **106** of the end system unit **102**, and the first **103** and second **104** port of the switch **101** form another (second) ring. Replicating or duplicating the packets with the quad box mode ensures a transmission of data between the individual rings, since data received at the first port **103** of the switch, for example, are transmitted both to the ring between the first port **103** of the switch and the second port **140** of the switch, and also output on the second ring via output to the fourth port **110** of the switch.

As a consequence, configuring the hybrid network end system device by means of the control device permits a diverse use in diverse topologies, which would not be economical to implement with conventional end systems utilizing separate switches. In addition, it becomes possible to build mixed ring and star topologies, wherein use can be made of the respective strengths of the topologies. For example, a ring topology can be used to minimize cabling, or a star topology can be used to enable a diverse cable routing.

FIGS. **10** and **11** show mixed ring and star topologies making use of the described hybrid network end system devices.

For example, several hybrid network end system devices **1003a**, **b** and **c** are used on FIG. **10** apart from conventional end system devices **1001** and conventional switches **1002**. The hybrid network end system device **1003a** is here operated in the first mode, which can also be referred to as the star or star mode. Connected therewith is a hybrid network end system device **1003b**, which is operated in the second mode, and can also be referred to as a mixed or mixed mode. In the present application, this hybrid network end system device **1003b** serves as a connection between a ring network and the star network. In turn, a hybrid network end system device **1003c** that operates in the third mode or quad box mode and connects two ring networks is in the present case connected with the ring network formed by the hybrid network end system device **1003b**.

As evident, the described hybrid network end system devices offer a wide variety of options and great freedoms in optimally configuring a network for communication using all possible topologies.

FIG. 11 here shows another system, which apart from the conventional end system devices **1101** and the conventional switches **1102** comprises two hybrid network end system devices **1103**, which each are operated in the mixed mode and each serve to couple a ring network into the star topology. Using two hybrid network end systems **1103** provides a redundant connection to the star network, which ensures a higher reliability by comparison to daisy chaining, for example, and thus enhances failure safety. At the same time, the cabling outlay in the ring network is minimized, which is optimal, for example, when cabling the wing of a cabin, etc.

Such a hybrid network end system device described above can preferably be designed for communication between aircraft systems, in particular airplane systems. In particular, a hybrid network end system device can preferably be designed for use in AFDX networks, and can be set up to support AFDX protocols.

However, such a hybrid network end system device described above can also be designed for use in an automobile (automobile end system) or in another vehicle (vehicle end system). This is advantageous in particular in vehicles where elevated requirements are placed on data transmission between end systems, such as sensors and control devices of a vehicle, owing to drive-by-wire, automated driving, etc. Autonomy along with driver assistance systems or Advanced Driver Assistance Systems (ADAS) are also to be mentioned here as keywords. Also provided are configurations for use in ships, industrial plants, etc.

The hybrid network end system device is preferably designed for deterministic network communication.

As known to the expert, end system devices or end systems are devices connected with a computer network that sit at the edge of the network. These end systems provide information and services. Expressed differently, end systems are devices whose applications access the network components, so as to transmit or receive data from the network, such as sensors, control devices, etc. In the case of AFDX, the end systems can be designed as AFDX end systems, which are part of an avionics or aircraft subsystem, which have to send data over the AFDX network, for example. Expressed differently, a subsystem, for example an avionics or aircraft subsystem, comprises an end system or an end system device as described above, which here is preferably designed as an AFDX end system device.

In another exemplary embodiment not shown on the figures, a second switch can be provided, which is connected with the second port **106** of the end system unit **102** and set up identically to the switch **101** described above and depicted on the figures. All statements thus apply accordingly. The second switch is here used for integration into the described second network of the network system.

Let it here be noted that the term “relay” is to be construed to mean that the data or at least the user data of a data packet are received at one point and output at another point. An adjustment of the data packet can here be provided, for example a change in the header or the like.

In addition, let it be noted that “comprising” and “having” do not rule out other elements or steps, and that “a” or “an” does not preclude a plurality. Let it further be noted that features or steps described with reference to one of the above exemplary embodiments can also be used in combination

with other features or steps of other exemplary embodiments described above. Reference numbers in the claims are not to be regarded as a limitation.

While at least one exemplary embodiment has been presented in the foregoing detailed description, it should be appreciated that a vast number of variations exist. It should also be appreciated that the exemplary embodiment or embodiments described herein are not intended to limit the scope, applicability, or configuration of the claimed subject matter in any way. Rather, the foregoing detailed description will provide those skilled in the art with a convenient road map for implementing the described embodiment or embodiments. It should be understood that various changes can be made in the function and arrangement of elements without departing from the scope defined by the claims, which includes known equivalents and foreseeable equivalents at the time of filing this patent application.

What is claimed is:

1. A hybrid network end system device for a network system, comprising:

an end system unit functioning as an end system unit of a network;

a switch integrated in the end system unit; and

a control unit;

wherein the end system unit comprises a first port of the end system for communication with the switch and a second port of the end system for communication with the network system;

wherein said switch has at least one first port of the switch and a second port of the switch for connection with the network system, and a third port of the switch for connection with the first port of the end system unit; wherein the control unit is configured to switch the switch into a first mode or second mode;

wherein in the first mode the switch relays data in a star topology between the ports of the switch;

wherein in the second mode the switch relays data in a ring topology between a port of the switch and a port of the end system unit;

wherein the end system unit comprises a local interface; wherein, in the first mode, the switch is configured to relay data received at the first port of the switch, the second port of the switch or the third port of the switch to either the first port of the switch, the second port of the switch or the end system unit via the third port of the switch; and

wherein, in the second mode, the switch is configured to relay data received at the first port of the switch to the end system unit via the third port of the switch, and relay data received at the third port of the switch to the first port of the switch;

wherein, if the control unit has switched the switch into the second mode, the end system unit is configured to relay data received at the first port of the end system unit to a second network via the second port of the end system unit, and relay data received at the second port of the end system unit to a first network via the first port of the end system unit; and

wherein, if the control unit has switched the switch into the first mode, the end system unit is configured to relay data received at the first and second port of the end system unit to the local interface.

2. The hybrid network end system device according to claim 1, wherein the switch is configured to relay data received at the first port of the switch, the second port of the switch, or the end system unit to either the first port of the switch, the second port of the switch or the end system unit.

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3. The hybrid network end system device according to claim 2, wherein the end system unit comprises a local interface.

4. The hybrid network end system device according to claim 3, wherein:

the first and second port of the switch is configured to be connected with a first network of the network system; and

the second port of the end system unit is configured to be connected with a second network of the network system.

5. The hybrid network end system device according to claim 1, wherein:

the switch further comprises a fourth port of the switch; the control unit is configured to switch the switch into a third mode;

in the third mode, the switch is configured to output incoming data at one of the ports of the switch to two ports of the switch, which are configured as outgoing ports of the switch of two network rings.

6. The hybrid network end system device according to claim 5, wherein, if the control unit has switched the switch into the third mode, the end system unit is configured to relay the data received at the first port of the end system unit to the second port of the end system unit, and to relay data received at the second port of the end system unit to the first port of the end system unit.

7. The hybrid network end system device according to claim 1, wherein the hybrid network end system device is configured to support communication between vehicle end systems.

8. The hybrid network end system device according to claim 7, wherein the vehicle end systems are aircraft end systems.

9. A network system for communication between end systems, the network system comprising:

at least one hybrid network end system device, each hybrid network end system device comprising:

an end system unit functioning as an end system unit of a network;

a switch integrated in the end system unit; and a control unit;

wherein the end system unit comprises a first port of the end system for communication with the switch and a second port of the end system for communication with the network system;

wherein the switch has at least one first port of the switch and a second port of the switch for connection with the network system, and a third port of the switch for connection with the first port of the end system unit;

wherein the control unit is configured to switch the switch into a first mode or second mode;

wherein in the first mode the switch relays data in a star topology between the ports of the switch;

wherein in the second mode the switch relays data in a ring topology between a port of the switch and a port of the end system unit;

wherein the end system unit comprises a local interface;

wherein, in the first mode, the switch is configured to relay data received at the first port of the switch, the second port of the switch or the third port of the switch to either the first port of the switch, the second port of the switch or the end system unit via the third port of the switch; and

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wherein, in the second mode, the switch is configured to relay data received at the first port of the switch to the end system unit via the third port of the switch, and relay data received at the third port of the switch to the first port of the switch;

wherein, if the control unit has switched the switch into the second mode, the end system unit is configured to relay data received at the first port of the end system unit to a second network via the second port of the end system unit, and relay data received at the second port of the end system unit to a first network via the first port of the end system unit; and

wherein, if the control unit has switched the switch into the first mode, the end system unit is configured to relay data received at the first and second port of the end system unit to the local interface.

10. A vehicle comprising:

at least one hybrid network end system device, each hybrid network end system device comprising:

an end system unit functioning as an end system unit of a network;

a switch integrated in the end system unit; and

a control unit;

wherein the end system unit comprises a first port of the end system for communication with the switch and a second port of the end system for communication with the network system;

wherein the switch has at least one first port of the switch and a second port of the switch for connection with the network system, and a third port of the switch for connection with the first port of the end system unit;

wherein the control unit is configured to switch the switch into a first mode or second mode;

wherein in the first mode the switch relays data in a star topology between the ports of the switch;

wherein in the second mode the switch relays data in a ring topology between a port of the switch and a port of the end system unit;

wherein the end system unit comprises a local interface; wherein, in the first mode, the switch is configured to relay data received at the first port of the switch, the second port of the switch or the third port of the switch to either the first port of the switch, the second port of the switch or the end system unit via the third port of the switch; and

wherein, in the second mode, the switch is configured to relay data received at the first port of the switch to the end system unit via the third port of the switch, and relay data received at the third port of the switch to the first port of the switch;

wherein, if the control unit has switched the switch into the second mode, the end system unit is configured to relay data received at the first port of the end system unit to a second network via the second port of the end system unit, and relay data received at the second port of the end system unit to a first network via the first port of the end system unit; and

wherein, if the control unit has switched the switch into the first mode, the end system unit is configured to relay data received at the first and second port of the end system unit to the local interface.

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